SCIENCE COMMUNICATION

Stakeholder perceptions of Real-time Incentive Fisheries Management

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This report seeks to minimise the use of scientific jargon in order to make findings accessible to the general public. The research outlines the views of Irish fishery stakeholders in relation to the novel proposal of real-time incentive (RTI) fisheries management. For the fully-referenced, scientific, peer-reviewed publication, see the Marine Policy journal article here.

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Summary

In these changing times, with political and environmental uncertainty surrounding us, fisheries management needs to become more adaptive in order to respond to the changes in our natural environment and changing management frameworks. Based on close to real-time information updates, and harnessing modern technology, Real-Time Incentive (RTI) fisheries management is designed to evolve with the fish stocks, enabling managers to respond more quickly and efficiently to management issues as they arise. Through the use of a credit system that makes use of regularly updated fine-scale information, incentives can be incorporated as rewards to encourage desirable actions such as data collection or 'fishing-for-litter' activities. However, in order for a new system such as this to be useful and become accepted, stakeholders must be involved in the development and design process.

This paper details the consultative process carried out with Irish demersal fishery stakeholders in an effort to identify their likes and dislikes of the system, and work towards tailoring the RTI system into a practical solution that works for them. In this process, we achieved a detailed understanding of the fishery, the complexity of the system, and the challenges faced by the stakeholders, all of which must be considered when attempting to implement a new management system such as RTI. A range of proposals were made by stakeholders, including new ideas for the future development of the RTI system. Most striking were the numerous ideas and approaches to tackling key issues currently facing the industry, many of which also have relevance to existing fisheries management. Given the freedom and support to do so, fishing industry stakeholders are eager to contribute to solving many of their own problems.

Keywords: Fisheries Management, Ecosystems Approach to Fisheries Management, EAFM, Commercial Fisheries, Stakeholder Perceptions, Incentives, Real-time, Spatial Management.

Contents

1. Introduction

Many fish stocks around the world are considered to be overfished. Overfishing refers to when the stock abundance of a fish is reduced by fishing to below the level that can produce maximum sustainable yield (MSY). Despite decades of science-based management, stock collapses have still occurred with considerable biological and social impacts. Fisheries around the world are in varying stages of development, as are scientific understanding, management and enforcement. The status of many fisheries are improving at the same time that peak exploitation is being reached in others. Despite the vast improvements in scientific knowledge and understanding in recent decades, our methods of management, and our understanding of the consequences of management have failed to advance as dramatically. Even within highly regulated areas such as the European Union, not all stocks nor all nations have the same level of resources, data or abilities, meaning that many species do not have full stock assessments. A lack of data, or of *reliable* data, means that many species cannot be assessed for sustainability. Furthermore, stock assessments are only performed for commercial species (*i.e.* those that are targeted for commercial sale), not for those impacted via bycatch or indirectly through food-web effects, leading to wider concerns about the ecosystem impacts of fishing.

Stock assessments provide fisheries managers with the information that is used in the regulation and management of a fish stock.

A wide array of biological data may be collected for an assessment. These include details on the age structure of the stock, age at first spawning, ratio of males to females in the stock, natural mortality, fishing mortality, growth rate of the fish, spawning behaviour, critical habitats, migratory habits, food preferences, and an estimate of either the total population or total biological mass of the stock.

Fisheries management usually operates on annual time scales, and thus is generally slow to respond to more rapid scale changes in the stock status or the ecosystem. Current EU management also operates over large spatial areas which are often only weakly linked to the actual fish distribution and exploitation, and updates are generally applied in line with the annual stock assessment review. However, even the most ‘traditional’ aspects of scientific fisheries management such as the stock assessments are currently undergoing a revolution. Fundamental changes in thinking from single-species, single-systems, single-problem approaches, to integrated assessment, multispecies models, mixed fishery concerns, ecosystem approaches and socio-ecological systems have occurred. Despite this, we tend to use the same old methods of management and implementation to solve these complex issues. To deal with the increasingly complex demands outlined above, a new way of managing fisheries is required.

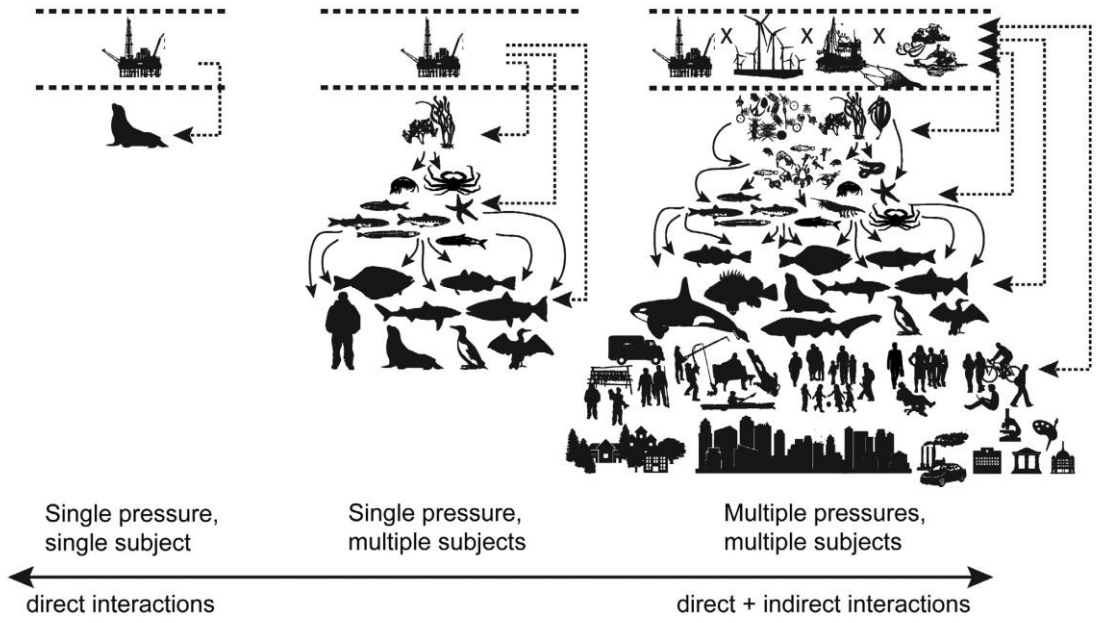
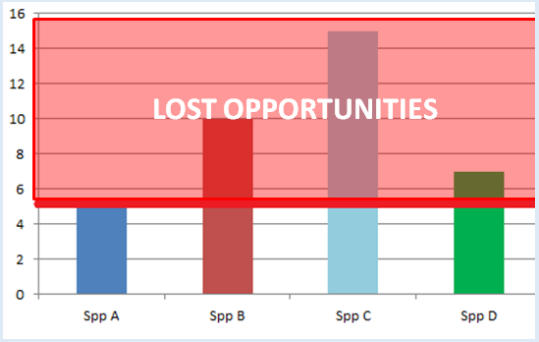


Figure 1. Conceptual framework for ecosystem risk assessment take from Holsman *et al.* 2017, illustrating the increasing complexity of assessments as we move from single pressures and single subjects through to multiple pressures and multiple subjects, and considerations of the humans as part of the ecosystem.

Over the last decade, there is increasing recognition among fisheries managers and ecologists that managing fisheries is about managing the actions of people acting on the resource (*i.e.* the fishers), rather than the fish themselves. As such the role of social science in fisheries management has become more salient as ecologists and managers recognise the need for improved social understanding to fully assess the effects of management interventions, analyse trade-offs (beyond economics) and to avoid unintended consequences. Furthermore, understanding fisheries as complex socio-ecological systems, highlights that humans are an integral dimension of the ecosystem: not separate to it, and should be treated as such. Humans both affect, and are affected by, ecological change (e.g. climate change). This move towards socio-ecological understanding has in parallel led to a growing need and appreciation for stakeholder *involvement* rather than stakeholder engagement, and the rise of 'co-' initiatives (co-management, co-design, etc.). Stakeholders are increasingly recognised as valuable and informative collaborators. Many initiatives are seeking to work with fisheries industry stakeholders as research partners to co-develop ways of improving sampling and coverage of fisheries data, engage fishers as citizen scientists, and even use their knowledge to inform historical fisheries activity and trends (e.g. see ICES WKIRISH, WKSCINDI, the National Oceanic and Atmospheric Administration (NOAA) Cooperative Research Program, and UNESCO workshops).

"Real-time incentive" (RTI) fisheries management is a novel management concept capable of responding to species distributions, and biological and ecological knowledge in a simple and

efficient manner. RTI can operate at a much finer spatial and temporal scale than traditional management approaches, and can be updated in close to real-time (e.g. weekly), through harnessing modern satellite and digital technology. In RTI, fishers are allocated fishing credits in place of single-species quotas, that are spent through fishing activity, paying a higher 'tariff' to fish at times and in areas that contain vulnerable species or ecosystem elements. Tariffs are regularly updated (weekly, bi-weekly, monthly as suits the fishery) in response to incoming information (e.g. landings/ catch from logbooks and satellite vessel monitoring system (VMS) records). Thus, species distributions are essentially 'tracked' as they change through the use of regularly changing tariffs. RTI helps to alleviate 'choke' species issues by providing close to real-time information on the location of quota-limited species to help fishers avoid them, and by allowing what is caught to be landed (reducing discards). Fishers are charged credits according to the tariff rate in the location in which they are active, through a digital on-board RTI console or app which provides the tariff maps and tracks current spending rates through a user-friendly interface (more info here). RTI also promotes the implementation of the ecosystems approach to fisheries management (EAFM) and enables fisheries managers to include spatial aspects into management objectives. For example, ecosystem elements such as vulnerable species and habitats can specifically be incorporated into the tariff calculation, requiring fishers to take these into account during their activities, comparable to the 'polluter pays' principle. Through the regular updates, RTI can adapt to changes in the fish populations, enabling efficient responses to management issues (e.g. overfishing or distribution change) as they arise, without the need for major structural changes to the system or new legislation. RTI helps to reverse the burden of proof in fisheries in two ways: first, fisher-provided data forms the



A **choke species** is a term used to describe a species with a low quota that can cause a vessel to stop fishing even if they still have quota for other species.

Demersal trawl fishers catch a wide range of species that live together in a mixed assemblage. However, the quotas (amounts they are entitled to catch) are for each species separately, like a shopping list. When fishing in these mixed fisheries, you cannot see what is going to come up in the net and so it is very hard to meet that list of quotas exactly. This means, that when you have caught all of your most restrictive species quota (in this case the blue species A in the diagram above), you are not allowed to keep fishing to catch the rest of your quotas. This potentially leads to a lot of missed opportunities, with serious economic implications for the fishing community.

The 'polluter pays' principle is the commonly accepted practice that those who produce pollution should bear the costs of managing it to prevent damage to human health or the environment

basis of the tariff maps. Secondly those wishing to avail of incentive schemes, in the form of cheaper tariff maps or additional credits, must be able to demonstrate the action/behaviour being rewarded. RTI works to engage stakeholders in co-management of the resource they exploit, whilst providing incentives for improved data gathering, behavioural modifications such as area avoidance (similar to the Scottish Conservation Credit Scheme), technical conservation measures (including proposing, developing, and trialling new selective gears) or positive contributions such as 'fishing-for-litter' or 'citizen science' activities, thus working to achieve wider social objectives.

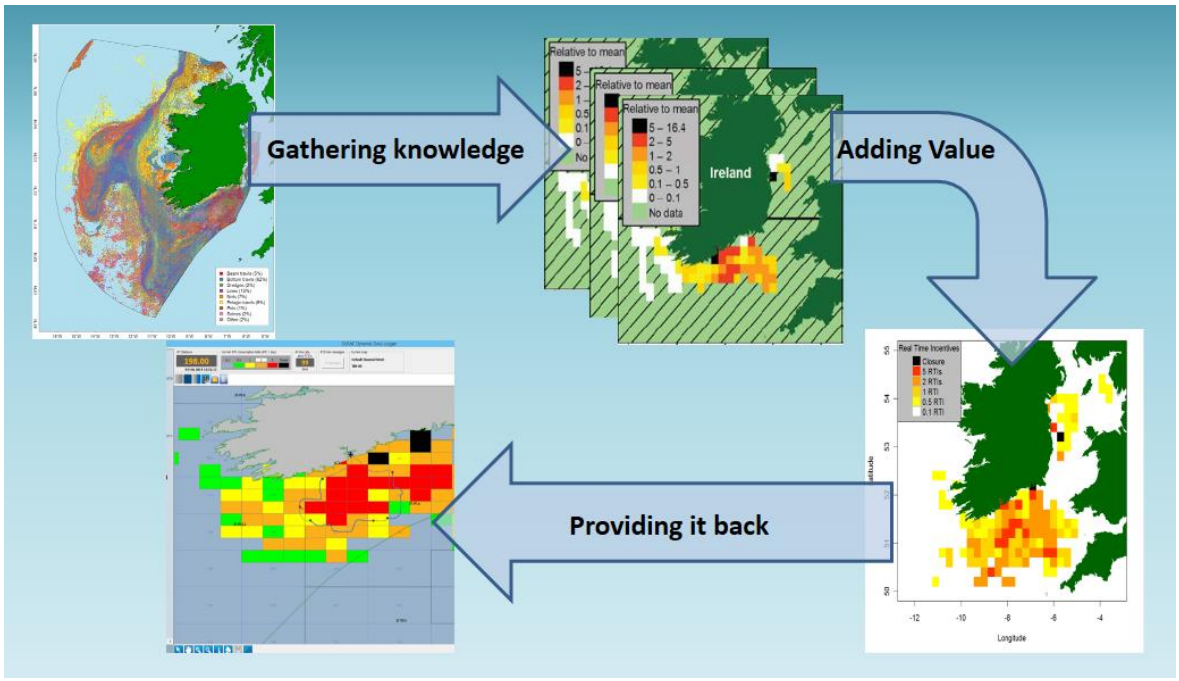


Figure 2. RTI concept diagram. RTI gathers existing data such as landings data from the fishers' logbooks and location data from the vessel monitoring satellite system (VMS) to produce distribution (green) maps for each species. These maps are then combined (based on stakeholder and manager priorities) to produce RTI tariff maps (white maps), which are then provided back to the fishers on a console on their vessel, so for the first time, fishers are using their collective data to inform fishing effort. These maps are then regularly updated on timelines suitable to the fishery (e.g. weekly or bi-weekly). Maps from Irelands Marine Atlas, Kraak et al. (2012) and the RTI website.

RTI has not yet been implemented in the real world. To move towards implementation, stakeholders must be consulted for their opinions, to identify objections and potential obstacles, and to identify areas for improvement. In this way we can use stakeholder input to co-design the system from the conceptual stage, using their input to design scenarios for management strategy evaluation (MSE), consult them on the MSE outputs, and work together to develop a practical pilot trial in the real world. Using the philosophy outlined above, this paper documents the feedback from fisheries stakeholders consulted in relation to the RTI management system, outlining their opinions, ideas and practical suggestions how to help

adapt RTI to their needs in the real world. We also report on the serendipitous information gleaned that could help improve fisheries management in general, and the value of working with fishery stakeholders in the context of a possible new approach to management.

2. Methods

Semi-structured interviews and small-group discussions were employed. These allowed as individual opinions and answers to open-ended questions around the RTI system and individual activities. As the majority of participants were unfamiliar with the RTI concept, an initial presentation was given during which participants could ask questions and seek clarification. Interviews were not restricted to RTI, but focused more broadly on fisheries in Ireland, issues and obstacles faced by individuals, opinions related to current management, and opportunities for improvement. A substantial portion of the interviews was also dedicated to the Landing Obligation (LO: EU 1380/2013, 2015/812). These aspects are reported elsewhere. The interviews were adapted to the role, circumstances, and preferences of the interviewees. Questions were prepared beforehand, with participants being allowed to dictate the flow of the conversation. If a topic was covered prior to a specific question being asked, the participants were not asked to repeat it, however in some cases they were asked to clarify/elaborate.

As it proved extremely difficult to recruit groups of industry stakeholders to take part at the same time due to conflicting locations and schedules, the majority of interviews were held individually, or in pairs. Two small group discussions (one group of two, and a second group of three) were also held to introduce the concept of RTI and answer initial questions. All bar one individual (who declined to be interviewed) from these groups were subsequently interviewed one-on-one to gain greater insight into their opinions and provide them with the opportunity to speak freely without colleagues around. Interviews took place in homes, offices, pubs, hotels, cars and on the quayside, as was convenient to the participant.

Twenty-one individuals were interviewed across 19 interviews. Interviewees ranged from active skippers and vessel owner-operators (totalling 13 interviewees), to shore managers, co-op managers, representatives from fisher representative bodies, and others involved in the fishing industry. Of the 8 non-fisher interviewees, 5 had substantial previous sea-fishing experience. Fishers interviewed represented 46 vessels, 34 of which were >12m in length representing 16% of the Irish registered polyvalent fleet (>12m), the focus of this study. The Irish polyvalent fleet includes multi-purpose vessels of all sizes, including small inshore netters and potters through to medium and large offshore vessels targeting whitefish, pelagic fish and

bivalve molluscs. All but one individual were male. Although the focus of this study is on demersal trawlers, two individuals are actively involved in the small scale fishery (generally <12m with static gears), which helped to provide a more holistic understanding of perceptions from within the fleet. Three interviews were from notes and post-meeting audio-recorded interviewer impressions only, all others were audio recorded and transcribed. Recorded interviews ranged from 44 to 127 minutes, totalling 1200 minutes with a median of 86 minutes. Variability in interview length was due to the semi-structured nature of the interviews, allowing interviewees to elaborate as desired.

Interviews were recorded, transcribed and anonymised to protect the identity of the individuals taking part. Permissions were sought by all participants prior to recording. Assurance of anonymity was key in facilitating recording of interviews. All information was held on password secured archive servers at the Marine Institute in compliance with the requirements under the EU General Directive on Personal Records (EU 2016/679). Where individuals declined to be recorded, notes were taken during the interview and interviewer impressions recorded directly after the interview. Participants were advised that they could request us to stop recording at any time. Interviews were transcribed and analysed, with codes assigned in relation to the topic of conversation. Codes relating specifically to RTI were filtered, selected, analysed, compared and reported here. Dedoose (2018: Version 8.0.35) was used for coding, charting and for examining code co-occurrence. A code co-occurrence matrix was used to indicate which codes and themes occurred together to provide greater insight.

The results presented here outline the likes, dislikes, suggestions and issues relating to RTI and fisheries management in general, and our efforts to incorporate them into its future development through a SWOT analysis (Strengths-Weaknesses-Opportunities-Threats).

3. Results

3.1 Coding

Eighteen codes were used specifically in relation to RTI (Table 1). Codes are identified throughout the text by using capital letters. Most codes are self-explanatory and refer to the item being discussed, such as a pilot trial for the system, or specifics relating to the technical aspects of the system. Comments that were favourable towards RTI were coded as RTI+, and those that were negative as RTI–. These codes were particularly important during coding as the primary focus was to find out which aspects appealed to interviewees or not. ‘RTI (interviewee description)’ refers to a section of the interview that asked interviewees to explain in their own terms their understanding of RTI. This helped to highlight which key aspects of RTI are most important or relevant to the interviewee.

Table 1. RTI codes used for analysis: how many times a code was used across all interviews, and co-occurrences both with other RTI codes, and with wider interview codes. 'Count' refers to the number of other codes each code co-occurred with, and 'Sum' refers to the number of times it was used in total (topics were often repeated throughout the conversation). Indent structure illustrates the nested/hierarchical structure of codes.

Codes used	Explicit code count (how many times code was used)	Co-occurrences			
		RTI Codes		Wider Interview Topics	
		Count	Sum	Count	Sum
RTI	133	16	169	147	415
Pilot	20	5	11	40	59
RTI (interviewee description)	10	7	14	15	17
RTI+	79	15	63	117	255
freedom/land what you catch	14	6	15	53	68
RTI-	28	11	24	59	96
Technical	36	12	43	58	95
RTI maps/ grid	42	12	51	54	87
golden rectangle	6	3	8	5	7
credits/tariffs	77	14	73	86	191
Charging	7	2	6	10	13
logging catch	22	11	16	49	87
other issues	11	6	8	30	37
real-time	10	10	17	27	32
spatial issues	32	10	31	61	92
Technology	22	5	9	71	108
temporal issues	25	10	31	27	47
sceptical/ cautious	35	13	34	64	100

For analyses comparing co-occurrences (things that were talked about together), there were 454 code co-occurrences between RTI codes throughout the text across 76 unique combinations (Table 2). The most frequent combination was between RTI MAPS/GRID and CREDITS/TARRIFFS (14 times) which makes sense as these are closely related. Both of these codes also co-occurred with TECHNICAL nine times. More informative are those between RTI+ and CREDITS/TARIFFS (11 times), FREEDOM/LAND WHAT YOU CATCH (9 times), followed by SCEPTICAL/CAUTIOUS (7 times). Those associated with RTI- were used less frequently (1-4 times) with the highest being a co-occurrence with SCEPTICAL/CAUTIOUS.

Table 2. RTI code co-occurrence matrix. Sum and count values in black exclude code 'RTI' (in grey); as a generic label, it was uninformative for analysis. Values above and below the grey horizontal boxes are a mirror image. Colour coding helps to pick out where the highest co-occurrences were observed (red for higher values, green for lower values).

	RTI	Pilot	RTI (int descrip)	RTI+	freedom/land what you catch	RTI-	Technical	RTI maps/ grid	golden rectangle	credits/tariffs	charging	logging catch	other issues	real-time	spatial issues	technology	temporal issues	sceptical/ cautious	
RTI		6	2	33	3	8	20	15	1	25		6	4	5	9	6	5	21	
Pilot	6			6			1			2				1				1	
RTI (int descrip)	2			3	1	1		3		3					2			1	
RTI+	33	6	3		9	4	3	6	2	11		1	1	3	2	4	1	7	
freedom/land what you catch	3		1	9		1		2				1						1	
RTI-	8		1	4	1		1	4		3		2		1	2		1	4	
Technical	20	1		3		1		9		9		2	1	2	4	1	7	3	
RTI maps/ grid	15		3	6	2	4	9			14		1		3	4	1	3	1	
golden rectangle	1			2						3							3		
credits/tariffs	25	2	3	11		3	9	14	3		5	2	2	1	6		6	6	
charging										5							1		
logging catch	6			1	1	2	2	1		2			1	2	2	1		1	
other issues	4			1			1			2		1				2		1	
real-time	5	1		3		1	2	3		1		2			1		1	2	
spatial issues	9		2	2		2	4	4		6		2		1			5	3	
technology	6			4			1	1				1	2						
temporal issues	5			1		1	7	3	3	6	1			1	5			3	
sceptical/ cautious	21	1	1	7	1	4	3	1		6		1	1	2	3		3		**Total** (excl. 'RTI')
Sum	169	11	14	63	15	24	43	51	8	73	6	16	8	17	31	9	31	34	454
Count	16	5	7	15	6	11	12	12	3	14	2	11	6	10	10	5	10	13	152

In addition to the codes in table 1, 272 codes covering 24 topics, spanning fisheries management, quota management, behaviour, Brexit, compliance, data issues, sustainability, the Landing Obligation, lifestyle/social, etc., that were not related specifically to RTI were discussed in the interviews. Of these, 75% (203) co-occurred at least once with the RTI codes (with a median co-occurrence of 5), highlighting that RTI has relevance across many aspects of fisheries. The top ten topics that occurred with RTI+ and RTI- are detailed in Table 3, and discussed in the next section.

Table 3. Top ten positive and negative code associations between RTI+ and RTI- and wider fisheries management issues. Overlapping areas are highlighted in grey, entries in bold text refer to RTI specific codes (see Table 1), regular text refers to wider fisheries concerns/issues.

Co-occurrences with RTI+	
credits/tariffs	**11**
freedom/land what you catch	**9**
TAC & quota	9
days at sea	8
effort	8
simplicity	8
sceptical/ cautious	**7**
ideas	6
tactics	6
lack of quota	6
Co-occurrences with RTI-	
TAC & quota	11
lack of quota	4
closed areas	4
vilification	4
RTI+	**4**
RTI maps/ grid	**4**
sceptical/cautious	4
fear	3
choke	3
credits/tariffs	3

3.2 SWOT Analysis

In order to identify the Strengths, Weaknesses, Opportunities, and Threats (SWOT) of/to RTI, the above co-occurrences were looked at in more detail, to identify trends, and support findings with quotes from the interviews. A high-level analysis is provided below, with quotes from interviewees provided *in italics*.

3.2.1 Strengths

For examining the strengths of the RTI system from the perspective of the interviewees, codes and excerpts relating to the code RTI+ were examined. RTI+ co-occurred with other RTI codes 63 times, and wider interview codes 255 times. The top ten aspects are outlined in Table 2, and reflect the favoured aspects of RTI from the perspective of the interviewed stakeholders.

Positive CREDITS/TARIFFS comments were generally associated with specific aspects, such as increasing flexibility compared to the status quo (particularly in relation to temporal planning throughout the year), receiving credits as incentives for sustainable actions (e.g. increased mesh sizes), and the fisher-proposed 'golden rectangle' (see 'Opportunities' section for details). The technical suggestion of limiting tariff increases to single incremental steps rather than potentially large swings in tariff rates when map updates occur was considered critical to allow for planning and adjustment periods.

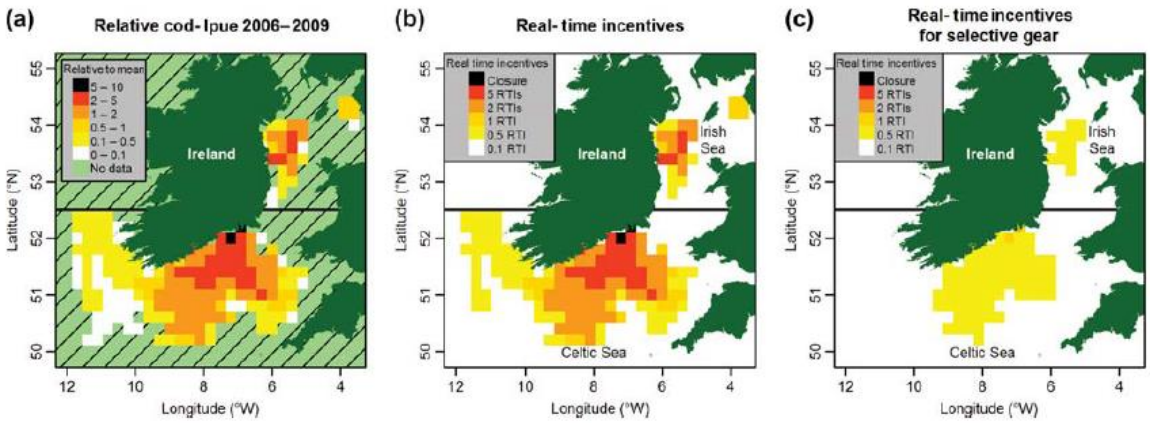


Figure 3. Under RTI management, the tariff maps are based off of the landings information (how much of a species was reported as caught). Map A illustrates a map of cod landings. Map B illustrates the simplest form of a map – one based on only one species – in this case, the cod landings from map A. Map B would be the standard map for vessels in this fishery. Map C illustrates a discounted map with lower tariffs that could be available for using a more selective gear (e.g. in this case, one that excludes or reduces your cod catch). Images from Kraak et al. (2012).

By far the most frequent specific positive comment made was in relation to being able to land what you catch. This was recognised as having multiple benefits, such as making fishing simpler, returning fishing practice to how it used to be (i.e. more seasonal), minimising discarding and improving data streams. Furthermore, it was recognised as more economically efficient through spending less DAYS AT SEA, with the added benefit of less discarding, and remaining compliant.

> *"The vast majority of boats would grab an opportunity to be able to work like that and go out there and fish like we used to 20 years ago with ease of mind and come in and land. Nobody wants to be dumping the bloody fish either."*

"I think if we had the right system, that you could land the fish, you would probably spend less time at sea. I don't think having credits would encourage you to go to sea, I think the fact that you can land fish would make you more comfortable about not having to go out as many days."

"I can see huge merits in this, absolutely huge merits in this…. a boat can go out and catch. If he has to bring in what he has on board he can't catch anymore. He's not going to put another boat over the side and fill that one as well too. He has to come in and land so he's going to go out in an area, catch as much fish that he can that will pay for him and come in and land right. And he stops fishing."

Interviewees also noted that the removal of monthly quotas would bring wider benefits, such as enabling fishers to better match catches to market conditions, and to plan their personal lives more freely without fear of losing out as the credits would be allocated for them to use throughout the year.

"I think if we had the right system, that you could land the fish, you would probably spend less time at sea. I don't think having credits would encourage you to go to sea, I think the fact that you can land fish would make you more comfortable about not having to go out as many days."

"What would appeal to any fisherman is that he could go out and catch fish and log it and land it, and not have to be juggling so much where to go, what to do. You wouldn't have to - it would take the worry out of it, 'what are we going to catch?' Especially if you're coming in with this landing obligation thing."

"I needn't go as far from home I'd say. There's plenty of fish available but there's no quota available so, I can stay closer to home or go further away….it would depend on the market then instead of the quota."

Positive RTI comments were frequently coupled with negative comments relating to TAC & QUOTA. These generally related to liking the concept of RTI, but being concerned about how it would operate under TAC, particularly in the context of Relative Stability (the key used for deciding the proportion of a TAC each EU fishing nation receives as a national quota) which leads to a perceived national LACK OF QUOTA, and a belief that TACs do not reflect the reality observed on the ground. Concerns around the relationship between RTI and national quota and how credits would be allocated to vessels accounted for the majority of the SCEPTICAL/CAUTIOUS codes (discussed further in next section).

TAC vs. Quota

Total Allowable Catch (TAC) is the maximum amount of fish from specific stocks that are allowed to be caught and are expressed in tonnes or numbers. TACs are set by the European Commission for each stock, and the TAC is then shared among the EU member states through **national quotas**. Individual member states then apportion these among the fishers in their country (individual quotas), and are responsible for ensuring that their quotas are not overfished.

"I really do like this, I think it's a good idea but like, it's a great idea if it's about killing less fish rather than trying to comply to a TAC level that is just not appropriate."

"The only drawback [of RTI] is the link to the TACs and the relative stability."

"...you know the biggest problem I would see with this probably is when its locked into our national quota…when you're locked into relative stability. I would fear that when people are logging away, bringing all the fish in, that our quota will run out very fast."

"…if you're still going to be limited to two and a half thousand tonnes of monk or whatever, you can't magic that to – like at the end of the day it's dead fish that pays for boats and if you've two and a half thousand tonnes, that's all you're allowed catch in the whole country, and I mean you can't magic it…"

In general, stakeholders liked the move towards days-at-sea, incentive and reward-based management, and the simplicity of the system for the user. Some individuals felt it would help them continue the way they want to fish, and that it was well aligned with how they fish now, with the added benefit of smart tools via real-time information.

Quota management manages *how much fish* fishing vessels are allowed to catch.

Effort management/ Days at Sea manages *how much time* fishing vessels are allowed to spend fishing.

RTI management manages *how much time* each vessel can spend *in a particular place* in order to meet the national quota set by the TACs, and avoid choke species.

"We're actually kind of fishing very similar to the way you envisage the RTI system going as it is anyway. We're constantly steaming around trying to avoid cod, or trying to avoid

haddock, or trying to find areas where there's predominantly whiting there. We're doing that as it is. Of course, the map would be a very good tool if you've got real-time information, of course."

"I think it would work very well for us, like, giving so many credits for so many areas and it's up to ourselves how we use them. It boils down to for me, working a bit like days at sea where it's up to you to work out where you want to go and how best you want to use your days….and I'm happy enough with that."

"I'd say it would be quite simple to work. Once there's a map there on the screen in front of you there should be no problem working it."

"It's effort management tied in with closing off boxes where there's high amount of pressures on stocks, which is great – I think it would really work, and it would really help."

"Effort is the way to go. RTI would be a move in the right direction."

In general, it was felt that RTI management would help to increase the choices of tactics, technical measures and behaviour that could be deployed to meet the challenges of mixed-fisheries trawling, coupled with the freedom to present their own ideas.

"I see the RTI thing as possibly having a bigger role in changing the behaviour with the gear types you use as much as the area you are. Because if you use bigger mesh and you release different sizes and stuff like that, shouldn't that be better?"

Ideas were presented for improving / tailoring the system (see Opportunities and Tailoring RTI sections). Individuals also highlighted specific aspects important to them beyond the top ten topics highlighted in Table 2, such as recognition as a useful conservation tool, that rewards responsible fishing, whilst increasing transparency and improving trust relations.

"It's more transparent and there's less onus on the boat, on the skippers to be compliant. You know there's so many rules and regulations to follow [now]*."*

"The real-time side of it, I think would be a very, very useful conservation tool. Absolutely."

"…its rewarding responsible fishing, and that's what you want to achieve is responsibility, and people being aware it's not an unlimited supply"

"...you're putting the trust in the fishermen, ….to see that by cooperating they can improve their own chances. With this they can say 'right I can cooperate and get more incentives'."

"I think is the best alternative management strategy that I have seen."

3.2.2 Weaknesses

For examining the weaknesses of the RTI system from the perspective of the interviewees, codes and excerpts relating to the code RTI- were examined. RTI- co-occurred with other RTI codes 24 times, and wider interview codes 96 times. The top ten aspects are outlined in Table 2, and reflect the least favoured aspects of RTI from the perspective of the interviewed stakeholders. Negative RTI codes were used approximately two thirds less frequent than positive codes.

The top two criticised areas in relation to RTI were TAC & QUOTA, and LACK OF QUOTA, which refers to the concerns around how RTI would work in the Irish context under the current TAC system with Relative Stability restrictions to national quotas. As noted above, these codes also occurred in relation to positive RTI (RTI+) comments showing some conflict in feeling. The current status of TACs and quota limitation felt by fishermen is seen as a limiting factor on the potential success of RTI. One interviewee who did not wish to be recorded, explained that although they considered the RTI system to be '*useful*', '*intelligent*', and '*helpful*' they also thought that it would not work with quotas the way they are, as the system is '*not unfair, its unjust'.* Others expressed similar opinions and concerns. This is such a major issue that nearly all of the remaining top ten codes are related to this key point. These include CHOKE, FEAR, SCEPTICAL/CAUTIOUS.

> *"…if you really want people to buy into this system, TAC has to be pushed to the side. It just has to be. It has to be. This has to be about killing less fish than we have done historically to catch our quota. Ok? That's what it needs to be about, and that's where the focus needs to go."*

> *"It's just the scepticism is the choke species, TAC hanging over your head, that, 'Christ there's loads of cod', we've to 'shut 'em all down lads'……You know, it is a major fear…."*

> *"But at the end of the day now if this was brought in tomorrow morning, I still only have a half a tonne of cod to work with for the month."*

> *"It would be excellent, and I could really see the benefit from it, but it's just harder, a lot harder, to see the benefit from it when you feel like you're hemmed in to the whole TAC thing as well."*

Other issues that were associated with FEAR and SCEPTICISM related to how RTI would be enforced (fear of CCTV monitoring) and compliance issues related to fishers' ingenuity in circumventing the rules. This also related to VILIFICATION as individuals felt that if cameras were required for fully documented fisheries, this would lead to an increasing lack of trust, and the perception that fishers are seen as intentionally destroying the stocks. VILIFICATION also

related to concerns about punishment for providing honest information, as they perceive to have happened in the past.

> *"...like anything we do, someone will find the little loophole and it's all gone out the window then, it's destroyed."*

> *"It's going to be looked at as zero trust by the fishermen, you know. And it's going to be looked at, and this is my own personal thing, but feck me they think we are criminals again."*

The CREDITS/TARIFFS and RTI MAPS/GRIDS concerns primarily related to the worries outlined above about how they would work within the limited quota, and whether this would lead to them becoming displaced from their traditional or familiar fishing grounds. Others outlined the 'psychological' impact of knowing where the good aggregations are, but it costing too many credits to get at them, whilst recognising that the reward would be that what you do catch would be legal, without having to discard commercial catch, or risk choking. A final key worry was in relation to what would happen if only one European nation would adopt RTI as a management strategy in shared waters, but other nations (with larger national quota for a given area) were able to access those maps. If this was to happen, RTI could close off areas nationally that were still accessible to other EU countries, while at the same time potentially highlighting the closed areas as a prime target to those nations not affected by the closure.

> *"You had these closures now in Scotland…the Scottish boats were around it, couldn't go into it, but yer man* [foreign registered vessel] *could quite legally go into it. And then he went on to that box, then this one and this one….and sure he was just having a big party inside there like, and the boys were around the place going [expletive] mad."*

CLOSED AREAS in general raised fears in relation to displacement. As RTI is a spatial management system, there were concerns about being unable to make a living due to displacement away from the familiar areas they need to fish. Beyond the physical displacement, interviewees highlighted the additional impacts in terms of time and psychological toll such disruption to their fishing activities may cause.

> *"I'd imagine I'd probably have to fish different areas obviously and further away from home at times I would imagine. I'd have to move round a lot more. I wouldn't like that, no, no. Like I said, I'm very traditional."*

> *"That's where our effort is. If you want to reduce the effort in those areas that's not fine. That will put boats to the wall, that will bankrupt boats."*

This implies additional costs, in terms of fuel, higher carbon emissions, additional wear and tear of the vessel, and potentially longer time spent at sea. Despite this, most interviewees accepted closures as a necessary and potentially useful conservation measure, provided closures applied to all fleets in shared waters. It was highlighted that depth contours should be taken into account to better map features of interest, and avoid excluding fishers from important fishing areas. Furthermore, fishers were in favour of monitoring closures to check their status and efficacy. There was general support for fisher-reported closures - real-time management actions based on fisher-reported information (e.g. influx of protected species, spawners, or for discard avoidance). Some interviewees felt that closures should not apply to the small-scale inshore fleet (vessels under 15m) as they are already limited in the areas they can access.

3.2.3 Opportunities

Opportunities for adapting and improving the RTI system were identified through two sources: the first, directly in response to questions of system design (outlined below in Tailoring RTI), and the second from the ideas proposed by interviewees. In general, participants recognised and appreciated the freedom an incentivised system such as RTI would bring:

> *"There's a lot of opportunities in this system in say mesh size, you know you can, if you use a bigger mesh size you can maybe get more credit…there's a great opportunity to make alterations in it."*

The Golden Rectangle was an idea proposed prior to these interviews by a fisher during a presentation of RTI to the industry. The concept is that a quota-holder can individually nominate a grid cell of their choosing that will always have a discounted tariff for that vessel. This serves to provide a 'safe space' where fishers know there is always somewhere that they can access to go fishing, and thus they will never be excluded from fishing (while they still have unspent credits in their account). This idea has been embraced by fishers, perhaps due to the fact that it was proposed by 'one of their own', with many voicing ideas for where they would like theirs to be, and how it should be implemented (whether static for the year, or bi-annually or seasonally variable). The Golden Rectangle was encouraged by both smaller vessel and larger vessel owners with the benefits to smaller fishers that cannot travel far being a key selling point, even for those with larger vessels. Complimentary ideas have been proposed, such as a 'Green Rectangle' in in which fishers could earn credits for carrying out specific activities, e.g. reporting on their non-commercial bycatch from key areas identified as relevant for monitoring for Marine Strategy Framework Directive status assessment and reporting. These ideas can easily be incorporated in the development of the system; the

discount rates or extra credits are simply absorbed across all other grid cells and thus the 'cost' to the system is minimal. However, their psychological benefit in terms of increasing stakeholder buy-in and ownership of the system are invaluable.

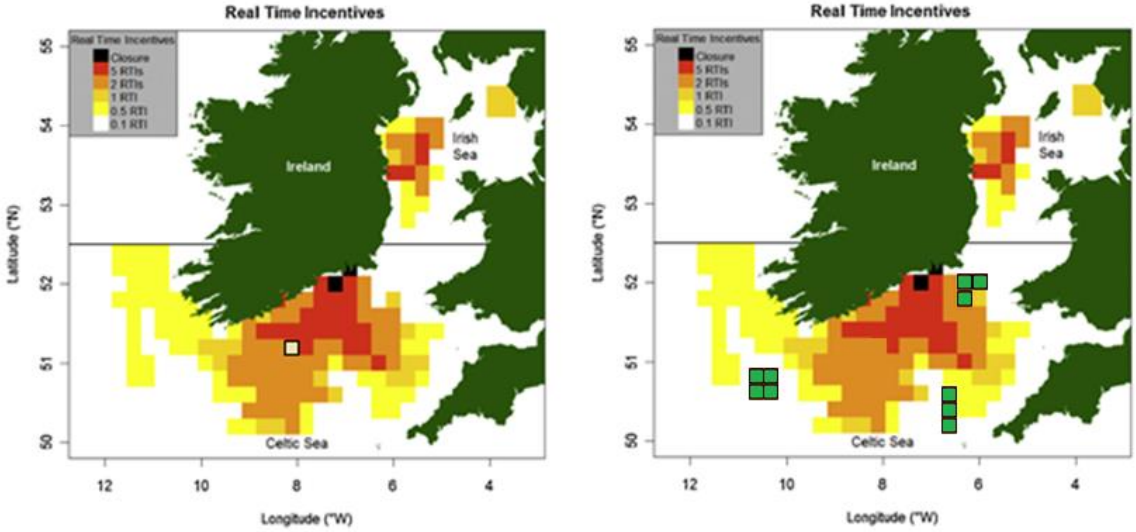


Figure 4. Illustrating the golden and green rectangles. Golden rectangles could be single grid cells nominated by a vessel as discounted to them (year round or seasonally as appropriate). Green rectangles, in which fishers could earn credits for certain activities, could be used to encourage fishing/information reporting/sampling in data poor areas. Both suggestions are anticipated to be feasible. Maps adapted from Kraak et al. (2012).

Protecting the inshore areas for smaller vessels was raised frequently among interviewees. Since the time of the interviews a policy directive has been introduced that excludes trawling by fishing vessels over 18 metres from inshore waters inside the six nautical mile zone from 1 January 2020. This will contribute to meeting these objectives; however, there is ongoing opposition from other parts of the industry to these measures.

Suggestions have been made to include target species size in the tariff calculations, particularly for the nephrops (*Nephrops norvegicus*) fishery, setting a higher tariff in areas with more small nephrops to protect the stocks and improve market prices. Similar ideas were proposed for crab, where there could be higher tariffs in areas with higher proportions of 'white' (moulted) crab. Others highlighted that in order to have a true idea of the effects of RTI, it would need to be based on more accurate data, as '*your model will be rubbish if based on logged catch data*'. The reasons for this are elaborated in Section 3.2.4.

Although the industry in general is wary about any further reporting burden, and many already feel 'over monitored', there were aspects where they would be willing to voluntarily share more information. For instance, trawlers have data on wing spread that are important for calculating swept area. This information is not usually shared with authorities or scientific agencies, but some interviewees volunteered this as one of the pieces of data they would not mind sharing.

Furthermore, one of the key issues with VMS is the low reporting frequency (every 2 hours). Most individuals were in favour of increasing its reporting regularity, but some suggested coupling VMS with a GPS (and perhaps a data logger), or the AIS (automatic identification system) to pinpoint catch locations more precisely. As these are already existing technologies, it was highlighted that this would help to make implementation more simple, quick and with minimal cost, and no additional technology burden. Most individuals objected to the use of winch monitors or cameras as they felt they were intrusive and unnecessary as the technology exists to monitor them in other ways.

Further discussion highlighted how RTI could be successfully coupled with existing sustainability certification schemes which require transparency and traceability. Coupling would allow for fine scale information to be input through the RTI interface, and shared (with permission) with sustainability certification schemes. This means the data need only be input once via the RTI console, thus reducing the reporting burden on fishers, but can serve two purposes: providing fine-scale scientific data for assessment and management purposes, and providing the audit trail required for sustainability certification. Certification then acts as a further incentive to fish sustainably and provide more data to RTI, as fishers can both earn credits and promote their product as sustainable.

Interviewees highlighted that there are very few existing information sharing networks within the Irish fishing industry currently. It was recognised that a reactive management system such as RTI would not only bring the benefits of a fleet-wide information sharing network (without personally identifiable information being shared), but also could provide an avenue for better communication with markets via processors flagging what has been landed to avoid market flooding and price drops. The current SFI funded Marine Institute *IFISH* project is looking at the benefits of implementing informal information sharing networks in Irish fisheries.

The idea of nudging through incentives instead of using direct regulation was received positively. Interviewees liked the idea of being rewarded for their efforts, but also identified opportunities for how incentives could be used to improve social capital, by providing more credits to individuals new to the fishery that have larger costs than those that no longer have the burden of vessel payments, or to reward vessels that take on new trainees, or scientists on board (e.g. observer programs). These points also highlight two of the major issues facing Irish (among others) fisheries currently: the increasing age profile of the fishers, and the lack of incentive/mistrust around taking observers on board that has been exacerbated by the introduction of the Landing Obligation. Conversely, individuals felt that the tariff rate a vessel is subject to should be related to the gear type/s used, with those with a greater negative ‘impact’ being subject to more stringent rates. The flexibility of RTI seems to provide the

environment for fishers to propose solutions to wide-ranging problems beyond the direct management of the fishery.

The ultimate opportunity is deployment of the system itself. RTI provides a framework of opportunity, in which fishers can offer solutions to their own problems and be rewarded for it through additional fishing opportunities (*i.e.* economic incentives), a 'land what you catch' system which fulfils the needs of the Landing Obligation, whilst avoiding choke issues and removing the incentive to discard catch. Many of the opportunities are highlighted by the predictions of the interviewees, including:

- a reduction in overall effort (fewer 'days at sea') compensated through increased economic efficiency due to minimised steaming and search times achievable via RTI map usage;
- market forces can be used to help regulate the price of fish;
- 'lifestyle' gains as fishers would have more time at home;
- safety gains through less time spent at sea during inclement weather and better planning opportunities through annual allocation of RTI credits as opposed to Irish monthly allocation.

These were illustrated via the below comments:

> *"If you want to change people's activities and their method of operation, the best way is their pockets, so if you can bring in a system that they will get more money for the same effort and for better fish, you will bring the rest on board."*

> *"I think that you will see some boats are fishing 300 [days] at the moment and they could actually go to 200 and be just as profitable. We do see in some fisheries where when regulation creeps in and the data improves and there is less in the market they get more for the fish anyway. So I think if you had more control, the amount entering the market isn't as much… maybe you just fish from Sunday night to Thursday night and I think that it could be just as profitable and I think there would be gains in lifestyle, you would be at home more, you could have a better life out of it."*

> *"…there was a days-at-sea system in place and the quota management system. I noticed that a lot of the fishing vessels are tying up in bad weather and fishing in good weather. Which as far as I am concerned is an excellent safety precaution for them."*

There was strong enthusiasm for pursuing a pilot trial, but also comments and predictions on the necessary preconditions (e.g. quota derogations and governmental support), along with predictions of how fishers might react, and ideas for tests between different fishing strategies.

A number of individuals thought the seine fishery would be most suitable for initial trial purposes.

> *"I think it would be very interesting having a much closer look at it yeah, and doing some trials on it yeah. For sure."*

> *"The system itself has massive potential. If it was to start in the morning and I'd kind of go, 'this is it'."*

> *"...put together your map, you've one guy working off 30 credits for the month, we'll say, just the arbitrary figure I'm just taking there, and another guy that's going out there solely for profit, or not even solely for* [expletive] *profit, just to fish the way he normally fishes* [under current quota management]*. And just see who kills more fish at the end of the month than the other. That's it! That's what it's about, and who kills more of what species……I think it'd be really, really interesting."*

There was general feedback about how the RTI MAPS/GRID should work; what spatial and temporal scales are appropriate (see later). However, there were also deeper insights into benefits that such a tool may have more widely as a communication tool between stakeholder groups.

> *"…if you're going to be having your updated maps on a regular basis, as we discussed, maybe the optimum is 2 weeks from our discussion the last day, but like obviously the NGOs and all the other stakeholders, they're feeding into this map as well like. I think it would be a fierce useful tool for dealing with that lobby. I really do like, I really do."*

3.2.4 Threats

There are a number of threats to the implementation of the RTI system, many of which are touched upon in the previous sections. RTI success ultimately depends on *how* it is brought in. Listening to the suggestions of stakeholders is critical in this respect, to maintain buy-in, ensure the system is practical and fit-for-purpose, and to capitalise on their knowledge and ideas. The primary threat relates to the quota limitation experienced by Irish fishermen. While this is not a threat to the RTI system itself as it can manage to any specified TAC, it is a threat to implementation in the Irish context. If the system does not keep fishers fishing for longer, or help them to earn more money (increase economic efficiency), it will be difficult to encourage them to change the current system, despite the many strengths identified by the interviewees and outlined above.

> *"…at the end of the day there'll probably be less of the species that you don't want killed - there'd be species protected by it. But next thing, we get to the situation where in June*

95% of all our quotas are caught, and what happens then? We're tied to the wall even though we've been promoting conservation!"

This project is currently carrying out a comparative evaluation of various management strategies which specifically aims to test comparisons between RTI and business-as-usual (TAC quota management), and report results both in biomass and economic terms. This will help to address the concerns related to choking and early tie-up.

Another challenge in maintaining buy-in is the long timelines that science and policy operate over. Many interviewees expressed frustration with this. Stakeholders were extremely enthusiastic to pursue a pilot trial of RTI immediately. Building *in silico* models over a number of years to test something before even getting to the real world is frustrating to them and can damage support.

A common misconception is that RTI is a push towards CCTV on board vessels. While it is one of the aspects that is incentivised, it is not mandated nor necessary for the operation of the system. Catch information on a haul by haul basis with fine-scale location information is ideal. However, the system can operate on only the information currently available: usually landings rather than catch information and 2 hour VMS reports. Interviewees had mixed reactions to logging catch as they haul it. Some were of the opinion that it is not a major issue, and that any fisher who says it is just wants to avoid extra work. Others however, felt that it was too much to ask within the physical demands and limitations of a busy wheelhouse. On small vessels with small crew sizes, we were told that there is not a spare person to do it, or that to do so would require hiring additional crew, and hence additional costs. A key message was that it is essential to ensure the technology is simple to use and effective. A button that could be pressed to log exactly when the gear was deployed and retrieved, coupled with an initial catch eye-ball estimation from the hold, could help to greatly improve data resolution. However, most interviewees were insistent that the full catch is unlikely to be logged until the end of the day.

"I think it's too much to ask, to log every haul, to be honest. I don't think there's any need for it."

"You can come up with simple ways, simple touch screen parts, that wouldn't be accurate but it should like give you kind of a rough log during the day. I mean if there was ten boxes in the haul, any boat will have 4 or 5 top priority species, and you just tick 1 or 2 or 4 or that. And then at the end of the day you would have an accurate tally from the hold, or something like that. So you would have an ongoing tally through the day to give you an indication. It can be done, you know, will it make it harder for the industry to live with? With what's currently out there [technology] it would."

Concern was expressed about costs, and who would pay for the new system. Previous experience has shown that introducing new systems has cost the industry; not just in financial terms for the initial outlay and maintenance, but also in time through inefficient design and down time due to upkeep of mandatory technology that restricts them from going to sea if not fully operational.

> *"You don't need to have cameras or big sophisticated technology. Think about it, if you've cameras you obviously need internet for all of that, who's going to end up paying for it? We paid for the VMS, we paid for the logbooks, we've ended up having to pay for everything!"*

> *"It's like electronic log books when they came in, right. We were told we had to have them, so they put a system on-board the boat that didn't work…I would literally go around at night time looking for a satellite signal…. if you put another monitoring thing in I guarantee to you it will become compulsory and if it is not working or there is a fault with it at sea we will be made to return to shore. Like we were with the electronic log book or if the VMS goes off."*

Misreporting represents a potential threat to the RTI system. Individuals revealed ways in which misreporting occurs, such as misreporting species by logging them as a species they have more quota for, and spatial misreporting, by assigning catch during logging to the wrong location. This presents a possible incentive to avoid mandatory logging as they catch, explaining the mixed perspectives above, as individuals will lose the freedom to misreport catches as it appears is routinely done. It should be highlighted that this is not viewed as non-compliance, but as a 'necessary evil' or 'habit' in order to make a living under the quota rules as they currently exist. Thus, there are social norms and cultural implications, along with practical implications, that need to be accounted for when implementing a new management system.

> *"I don't think you should have to do that like, but you can put down, if you got a lot of cod in this area, you could put down whiting for it or something, but that isn't cheating, its habit."*

> *"The mis-recording it isn't that bad, it just isn't that bad. There is a bit of interspecies and there is a bit, there are things, but as a percentage it's only in certain species so it's not across the board."*

> *"Log book is the book of lies hey? What I don't agree with is having to steam maybe forty miles to log fish that you didn't catch in that area."*

> *"It is a fundamental problem but it is certainly not the end of the world type stuff. It's not as bad as that it just totally undermines everything, it's not that bad. What I would say is that you need to recognise in the project that this is a problem. And so you need to say how can you overcome that and the way to overcome it is to suggest a pilot project of pure data from a boat that is unfettered by the current regime."*

It was suggested the best way to introduce a new system is to 'reset the system' and introduce it under an amnesty basis that allows individuals to provide honest information without fear of repercussion. The majority of interviewees believe the science is wrong, because they know the logbook data is wrong. Stock assessors understand that the data is wrong, and take it into account, adding to their errors and uncertainty and leading to a less precise assessment, which further perpetuates the science-is-wrong perspective. Despite stating a strong preference to be able to land what they catch, and to provide real, honest information, fishers also fear what this would mean from a management and enforcement perspective.

> *"…if we were to do it, the scientific people may have to accept that they would see more fish than they think is there. That would definitely happen, that is an absolute guarantee that that would happen."*

A final threat identified by interviewees to the successful implementation of RTI management is the ingenuity of the fishers themselves. Fishers have years of experience in identifying ways to circumvent rules they see as unfair or unjust, or simply in pursuit of profit. Interviewees were asked to identify ways in which they thought RTI could be 'cheated', and unsurprisingly, most were reluctant. Some thought spatial misreporting would be the main way, others pointed out that high-grading would remain an issue, as there will always be an incentive to maximise profit, even under a "land what you catch" scenario. A number of individuals thought the biggest threat was their own ingenuity.

> *"Like anything we do, someone will find the little loophole and it's all gone out the window then, it's destroyed."*

> *"…that thing looks good on paper but I just think fishermen are just gonna try and find every which way around it they possibly can."*

3.3 Tailoring RTI

In order to design a system that is fit for purpose, interviewees were asked for their opinions on practical aspects of RTI management. This provided participants with the opportunity to adapt the system to their needs, and propose their own ideas and solutions. The ideas and feedback have fed into the design of this projects (and future) MSE scenarios for testing the system through modelling and simulations and will inform any future real-world trials.

In order to facilitate 7-10 day trips, the ideal preference for temporal updates was selected as every two weeks. This was considered more fuel efficient (one trip instead of two), whilst maintaining close temporal links to the stock movements and catch observations. It was noted that this would mean that any real-time closure would last a minimum of 2 weeks also, but it was deemed an acceptable trade-off.

For scientific mathematical and modelling purposes (i.e. in the MSE), hexagons work well for the tariff map, with their central point being equidistant to all surrounding hexagons. However, vessels, and their captains, operate on latitude and longitudinal basis. Therefore, it was deemed essential that the maps operate off a square or rectangular grid. ICES statistical rectangles were used as a basis for grid cell proposals. Three proposals were put forward as a discussion starting point: an ICES statistical rectangle (~56km x 73km at Irish latitudes), a quarter of an ICES rectangle (~28km x 36km) and sixteenth of an ICES rectangle (~14km x 18km). The middle option was favoured, however many individuals highlighted that the spatial scale relevant for smaller inshore vessels, static gears, and nephrops fisheries would need to be tailored to those fisheries. We must be aware of the human propensity to select middle options as a more comfortable safe-ground (the compromise effect), rather than an absolute preference, and bear this in mind during any implementation. It is likely that the spatial scale may need to be modified to better reflect the scale of activity. This highlights the necessity for further MSE work to test different spatial scenarios, and *in vivo* pilot trials prior to implementation.

A range of options exist for how tariffs could be charged. Vessels could be charged for all cells visited, or only for cells in which fishing activity was identified/reported. Interviewees felt that vessels should only be charged for the rectangles in which they actually fish (rather than those they ‘steam’ through). This feels intuitively fairer, however demonstrating whether a vessel is steaming rather than fishing requires more fine-scale location information than currently provided to scientific and management authorities. It may be that a more accurate charging algorithm can be used to ensure charging only where fishing occurs, when vessels provide more fine scale catch information that managers desire. This was understood by participants as reasonable and fair – a more stringent map where the information provided is poorer. There was concern that this may result in vessels fishing closer to shore if they are going to be charged for every grid cell they enter, but ultimately the (predicted) cheaper offshore grid cells were deemed to be sufficiently tempting for the larger boats. Currently, fishing activity is identified through changes in average speed as calculated from VMS location information. However, this can be manipulated, with vessels travelling to other ICES areas for shorter periods in order to mis-log their catch in an area for which they have quota for the caught species. It was highlighted that if we operate (at least initially) off the current system, there

must be a way to report when there is a vessel fault (e.g. engine fault), or when travelling at slower speeds than normal due to inclement weather so that they are not mid-identified as fishing events. Furthermore, it is not clear how charging will occur across multiple activities throughout a day, or over the course of a trip. If credits are 'fishing day equivalents' (FDE), a concept that sits well with the interviewed stakeholders, it would seem to make sense that credits are charged on a daily basis, at a rate that is the mean of the cells visited/fishing locations. However, we must be careful to ensure that this is not open to abuse such as logging activity in lower tariff cells to decrease their overall credit charge.

On a policy level, a general preference for maintaining state-ownership of the credits was apparent, and for maintaining the existing quota categories (vessels above and below 16.76m). Under current Irish quota management, the larger vessel category receives twice the quota allocation of the smaller vessels, and capacity (tonnage) cannot be swapped between vessel size classes. Although a transition to RTI would likely remove the need for such a vessel-size category quota break, as vessels can land what they catch and the size of the vessel limits its harvesting capability, participants felt the size distinction should remain in legislation to maintain continuity of vessel size class as fishers had built their business plans on this basis. It is likely that other regions/countries would demonstrate similar preferences (*i.e.* retaining the status quo).

Some individuals were initially in favour of making credits transferable in order to deal with the landing obligation, however under RTI, this would not be necessary as vessels can land what they catch. Once this was understood, the majority remained in favour of non-transferable credits. There were queries as to whether credits could be transferred from one year to the next by an individual vessel. This arises from concern that individuals could possibly lose out on credits (fishing opportunities) if they have not used them all within the year. This is a decision to be made by policy-makers in conjunction with stakeholders prior to implementation, and its consequences tested in MSE.

Some interviewees stated a preference for credit allocations to remain the same each year, and for the tariff rates and maps to change annually. This is linked to psychology where participants acknowledged the 'pain' of receiving less credits than they had the year before. For the use of incentives, two approaches were preferred, depending on what was being rewarded. For using TCMs or FDF for instance, a lighter tariff map could be provided. However, for voluntarily taking part in other initiatives such as fishing for litter, citizen science data provision, information sharing, etc. a bonus in the form of additional credits would be preferable. This would also help to avoid having 'too many maps' circulating, i.e. many fishermen fishing with different tariff maps.

For the initial starting RTI map, there was a strong preference for starting with a blank map (no tariffs) and letting them build up in relation to the fishing activity. This was predicted to help participants understand how the maps are built. Other options include a starting map based off the same week the previous year/s, or an average of the previous year/s, or even a stakeholder map. As species timing and distributions are so variable at present, maps based on previous activity were seen as potentially misleading. Stakeholder-built maps were seen as potential conflict areas and time consuming. A blank map felt fairer to participants, and psychologically more appropriate to the introduction of a new system. A physical representation of the 'clean sheet'.

A final aspect that was highlighted was concern around certain 'lightning strike' species/catches. These are (quota) species that can show up in great numbers, relatively suddenly, and when caught can result in choking/ over-quota catch. Fishers were worried that these species could drive up the tariffs quickly as catch rates increase exponentially when they arrive (migratory species for instance). We indicated that if these species are not included in the tariff setting, they will not drive the tariffs, and if they are, a seasonality component can be taken into account for setting the rates. This was identified as a key area where fishers could contribute information of 'on the ground' observations to trigger management action. Furthermore, the incremental nature of the tariff increases mediates the impact of sudden influxes of particular species.

4. Discussion

Real-time Incentive (RTI) fisheries management was generally positively received by the fisheries stakeholders interviewed here. Although responses were varied, positive comments were more frequent than negative comments, with negative comments being generally associated with the ways in which it would potentially integrate with current fisheries management. A wide range of useful feedback was forthcoming, with individuals eager to provide input and ideas, and grateful for the experience and to have their ideas valued. This feedback was not only very valuable for co-developing RTI, but also revealed many, valuable details of stakeholder's views on the future of fisheries management.

Identifying, locating and "pinning down" participants is never easy, and the logistics of finding a mutually agreeable time and place to interview were challenging. In general, sampling was considered to have reached sufficient levels as there was considerable redundancy in the topics raised, however complete saturation had not been reached as the occasional new idea and/or issue still arose by the end. Despite this limitation, we believe we have achieved

reasonable coverage of the demersal fleet, and included other industry stakeholders to ensure diversity of opinion and perspective (i.e. variation sampling). However, there is distinct gender-bias in our sampling. This is partially due to the male-dominated nature of the fishing industry, coupled with the less visible, and thus less accessible, roles of women within the industry. It is likely these women would have a useful and unique perspective on the RTI system, and its potential impacts. As the RTI project is ongoing, and an iterative stakeholder process is in place, new ideas and suggestions will continue to be gathered and used to further develop the project and further through to any pilot phase. Efforts will continue to include female perspectives where possible. In addition, future plans include gathering perspectives from environmental non-governmental organisations, scientists, and managers. This will add to the valuable information gained here, and provide more holistic feedback on the RTI system.

The greatest obstacle to RTI management was identified as integration with the current TAC and quota management system. While RTI can operate under the current management system, bringing with it a wide range of benefits, the issues raised warrant discussion. The E.U.'s current mode of allocating proportional TACs according to historical fishing practices (Relative Stability) is outdated, does not meet the goals of sustainable fishing management, does not match well with economic dynamics, fails to facilitate the ecosystems approach to fisheries management, and is almost impossible to adhere to in the context of mixed fisheries and the Landing Obligation. If we are to meet the stated Common Fisheries Policy goals of 'long-term environmental, economic, and social sustainability', and 'protection of the marine environment, to the sustainable management of all commercially exploited species, and in particular to the achievement of good environmental status by 2020', then we may need to reconsider some of the wider questions of how fisheries opportunities are allocated. TAC allocations on the basis of historical political decision-making does not take into account improved scientific knowledge, understanding, and technological change over that time period, nor the changing distributions and abundances of species over recent decades, in response to climate change. RTI provides an opportunity to manage to the close to real-time temporal and spatial distributions of species, using 'smart' technologies, whilst improving data flow, providing opportunities to incentivise a wide range of desirable behaviours, avenues to include fisher ecological knowledge, protecting vulnerable ecosystem components from the ecosystem effects of fishing (e.g. benthic impacts:), and facilitating fisher-led problem-solving (e.g. gears, mesh sizes, behavioural changes, etc.).

Many challenges remain before RTI could be implemented in the real world. Adapting the system to multi-national demersal fleets within shared waters, and to include such diverse fisheries as industrial pelagic fisheries, through to small-scale static inshore fisheries, including non-quota species is a key challenge. Related to the current work, questions about

how RTI management can be applied in the context of less mobile fisheries, such as the highly profitable but spatially restricted nephrops fishery, presents another key challenge. However, even in this context, our interviewees have made suggestions, such as basing tariffs on the size of the nephrops, and incentivising vessels with more selective gear measures in place (e.g. separator panels). Further challenges remain in how the algorithms are calculated and adapted, data systems managed, the roles for each of the agencies (e.g. enforcement, scientific, management), and any legal implications for the deployment of such a system. These are areas for future development and research.

Perhaps naively, an unforeseen outcome of this work is the number of ideas and level of innovation present among industry stakeholders, and well beyond the scope of co-designing an RTI system. Unsurprisingly interviewees were well-versed on the issues facing their fishery. However, the level of openness to innovation and problem-solving abilities were unanticipated. It can be easy to paint fishers as a monolithic group chasing after a traditional way of life, or conversely as 'plunderers of the sea' out for all they can catch, but the reality is much more nuanced. The participants were fully aware of the complex political, social and environmental context in which they operate, and feel they are frequently facing negative public perception, institutional and political roadblocks and environmental decline, and yet they remain eager to work towards overcoming these issues. Many were delighted to simply have the opportunity to engage in 'blue skies' thinking, with the freedom to propose solutions to the problems they observe. Reviewing both the positive and negative aspects of RTI provided an open environment in which ideas could be proposed and critically appraised – many of which have applications outside of RTI management, contributing to the wider conversation on how we manage our fisheries into the future.

In the context of RTI, there were a number of surprising suggestions with a wider resonance for fisheries management. For example, suggesting lower tariffs for new fishers entering the industry, or as a reward for taking observers on-board, or that vessels using gears with greater benthic impact should "pay" a higher tariff indicates how other incentive schemes might work, and the types of incentives fishers are eager to see. Interviewees were willing to share information about misreporting mechanisms, with the aim of creating a fair and equitable new system, whilst acknowledging that often the biggest challenge to the system is the fishers themselves. This provides important insight into the operation of current management, the cultural context, and issues that must be tackled from the inside out if they are to be rectified. Interviewees were also broadly in support of fishing closures, particularly when industry-led, and supported the need for monitoring and evaluation of those closures. They expressed a willingness to share gear performance and CPUE data with scientists, and provide more accurate haul location information, provided the system incentivised this. More broadly, they

understood the value of the information collected under RTI to improve the scientific data, and hence the accuracy of stock assessments, support sustainability certification and transparency for marketing, as well as the value of that information to processors, the retail sector, and the general public. Finally, the potential benefits for safety of not "having to go to sea" in bad weather, or when the fish were less productive, or spawning, was clearly understood and recognised as a move back towards 'seasonal fishing' habits more reflective of historical fishing practices.

A number of lessons can be learned from the broadly forthcoming nature of the stakeholders being interviewed. We did not go out to discuss current fisheries management. The aim was principally and transparently to tailor a new approach. However, the stakeholders were eager to broaden the discussion, suggesting how fisheries management might be improved. It is likely that the approach of discussing a new management system opened the gates for innovative free thinking beyond the usual confines of fisheries management discussions, enabling fishers to propose their own solutions to the problems they observe within the fishery. Interviewees were positive, thoughtful and imaginative about how to improve fisheries management, providing valuable feedback and sparking new ideas. This is the beauty of the semi-structured and largely open format of these interviews. It is also important to remember that 'stakeholder engagement' is not only about asking stakeholders for information, or showing them a finished product and "consulting" them about it, but to truly engage them in the process from the early development stages.

For the future development of RTI, it is important to think more about 'how' we implement measures, not just 'what' we implement. How can/should we integrate a new management system into the social fabric of an industry and its communities? What fora should be used to facilitate discussion and decision-making in relation to tariff-setting? At what level should tariff-setting discussions occur? Should these build on existing platforms such as the E.U. Advisory Councils, or more local regional bodies (such as the Irish Quota Management Advisory Committee, National/Regional Inshore Fisheries Forums), and if so, how do we make them more transparent and accessible to a range of stakeholders? These challenges are significant and remain to be investigated further.

This paper has highlighted which aspects of RTI are expected to work, and identifies those that aren't. This early consultation has helped to detect issues early on to avoid 'ivory-tower' designing, which often results in systems that fail to work on the ground. Much is still to be learned through the trial and error of a pilot phase, but early discussions with the potential end-users of such a system can save time, and avoid wasting resources. Furthermore, working directly with stakeholders helps to gauge interest on the ground, whilst providing an

opportunity for input into the development of the system, which itself helps to improve user buy-in. Indeed, the biggest message received from the industry stakeholders is 'when can we try it?'

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For more information on the RTI approach and investigations to date, please see:

- http://rti-for-fisheries.info/
- S.B.M. Kraak, D.G. Reid, H.D. Gerritsen, C.J. Kelly, M. Fitzpatrick, E.A. Codling, E. Rogan, 21st century fisheries management: a spatio-temporally explicit tariff-based approach combining multiple drivers and incentivising responsible fishing, ICES J. Mar. Sci. 69 (2012) 590–601. https://doi.org/10.1093/icesjms/fss033.
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